CHAPTER 10: NATIONAL IMPACT ANALYSIS

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CHAPTER 10. NATIONAL IMPACT ANALYSIS

10.1 INTRODUCTION

This chapter describes the U.S. Department of Energy's (DOE's) estimation of certain national impacts that may result from potential energy conservation standards for heating products. Results described here include: (1) national energy savings (NES) from considered standard levels, (2) the monetary value of those energy savings, (3) increased total installed costs and maintenance and repair costs that are attributable to energy conservation standards, and (4) the net present value (NPV) of the difference between the value of energy savings and the total costs.

DOE determined the NES and NPV for all the standard levels considered for the three heating products under consideration: residential water heaters, direct heating equipment (DHE), and pool heaters. All calculations for each of the considered products were performed using a Microsoft Excel spreadsheet model, which is accessible on the Internet (www.eere.energy.gov/buildings/appliance_standards/). Each product's spreadsheet model, referred to as a national impact analysis (NIA) model, incorporates the calculations for determining the NES and NPV as well as inputs from the associated shipments model. Details and instructions for using the NIA models are provided in appendix 9-A, User Instructions for Shipments and National Energy Savings Spreadsheet Model. Chapter 9, Shipments Analysis, describes the shipments models that DOE used to forecast future purchases of the considered products.

10.2 TRIAL STANDARD LEVELS

DOE generated NES and NPV results for specific trial standard levels (TSLs). The TSL for each heating product consists of a set of efficiency levels for each product class for water heaters and direct heating equipment, and a single efficiency level for pool heaters.

For water heaters, since amended water heater standards will apply to the full range of storage volumes, DOE is showing the TSLs for water heaters in terms of the energy efficiency equations, rather than only showing the efficiency at the representative capacities. DOE is using the alternative energy-efficiency equations developed in the engineering analysis for the Final Rule.

For TSL 1, 2, 3, 4, 6,7 and 8 (i.e., all TSLs except TSL 5), DOE is using the rated storage volume divisions and the energy efficiency equations developed in the engineering analysis, which specify a two-slope approach. TSL 1 consists of the efficiency levels for each product class that are approximately equal to the current shipment-weighted average efficiency. TSL2 and TSL 3 consist of efficiency levels with slightly higher efficiencies compared to TSL 1 for most of the product classes. TSL 4 represents the maximum electric resistance water heater efficiency across the entire range of storage volumes that DOE analyzed for electric storage water heaters, and the maximum atmospherically-vented efficiency across the entire range of storage volumes that DOE analyzed for gas-fired storage water heaters. TSL 7 is identical to TSL

4 except DOE is considering a heat pump water heater level for electric storage water heaters across the entire range of storage volumes, which is compatible with ENERGY STAR criteria for electric storage water heaters at the representative rated storage volume. TSL 8 consists of the max-tech efficiency levels for each of the water heater product classes at the time the analysis was developed.

For TSL 5 and TSL 6, DOE further modified the two-slope approach developed in the engineering analysis. DOE wanted to consider a pairing of efficiency levels that will promote the penetration of advanced technologies into the electric and gas-fired storage water heater markets and potentially save additional energy. Consequently, DOE is pairing an efficiency level requiring heat pump technology for large-volume electric storage water heaters with an efficiency level achievable using electric resistance technology for small-volume electric storage water heaters. In addition, DOE is pairing an efficiency level requiring condensing technology for large-volume gas storage water heaters with an efficiency level that can be achieved in atmospherically-vented gas-fired storage water heaters with 2 different level of increased insulation thickness for small storage volumes.

In addition to pairing different technologies for small and large volume products for TSL 5 and 6, DOE also modified the division point between small-volume and large-volume gas-fired and electric storage water heaters. DOE used an analysis of market data to determine the initial division points, which were 60 gallons for gas-fired storage water heaters and 80 gallons for electric storage water heaters. These division points are used to modify the two-slope equations for TSLs 1, 2, 3, 4, 7, and 8. Because DOE is pairing two different technologies for consideration as an amended standard in TSL 5 and TSL 6, DOE is concerned that manufacturers may attempt to circumvent the increased standards for large-volume water heaters by producing water heaters at volumes just below the division points. DOE has chosen to modify the division points for TSL 5 and TSL 6 to 56 gallons for gas-fired and electric storage water heaters to attempt to mitigate the potential loophole. TSL 5 and TSL 6 include efficiency levels that require heat pump technology for electric storage water heaters with rated storage volumes at and above 56 gallons, and efficiency levels that require condensing technology for gas-fired storage water heaters with rated storage volumes at and above 56 gallons. Based on its market assessment, DOE estimated approximately 4 percent of gas-fired storage water heater shipments and 11 percent of models would be subject to the large-volume water heater requirements using the TSL 5 and TSL 6 division. Similarly, DOE estimated approximately 9 percent of electric storage water heater shipments and 27 percent of models would be subject to the large volume water heater requirements using the TSL 5 and TSL 6 division.

Table 10.2.1 shows the energy-efficiency equations and associated two-slope divisions for TSLs 1 through 8.

Table 10.2.1 Trial Standard Levels for Residential Water Heaters (Energy Factor)

Trial Standard Level	Energy Efficiency Equation	
TSL 1	For GSWHs with a Rated Storage Volume at or below 60 gallons: EF = 0.675 – (0.0015 x Rated Storage Volume in gallons)	For GSWHs with a Rated Storage Volume above 60 gallons: EF = 0.699 – (0.0019 x Rated Storage Volume in gallons)
	For ESWHs with a Rated Storage Volume at or below 80 gallons: EF = 0.967 – (0.00095 x Rated Storage Volume in gallons)	For ESWHs with a Rated Storage Volume above 80 gallons: EF = 1.013 – (0.00153 x Rated Storage Volume in gallons)
	For OSWHs (over the Entire Rated Storage Volume range): EF = 0.64 – (0.0019 x Rated Storage Volume in gallons)	
	For GIWHs (over the Entire Rated Storage Volume range): EF = 0.82 – (0.0019 x Rated Storage Volume in gallons)	
TSL 2	For GSWHs with a Rated Storage Volume at or below 60 gallons: EF = 0.675 – (0.0012 x Rated Storage Volume in gallons)	For GSWHs with a Rated Storage Volume above 60 gallons: EF = 0.717 – (0.0019 x Rated Storage Volume in gallons)
	For ESWHs with a Rated Storage Volume at or below 80 gallons: EF = 0.966 – (0.0008 x Rated Storage Volume in gallons)	For ESWHs with a Rated Storage Volume above 80 gallons: EF = 1.026 – (0.00155 x Rated Storage Volume in gallons)
	For OSWHs (over the Entire Rated Storage Volume range): EF = 0.66 – (0.0019 x Rated Storage Volume in gallons)	
	For GIWHs (over the Entire Rated Storage Volume range): EF = 0.82 – (0.0019 x Rated Storage Volume in gallons)	
TSL 3	For GSWHs with a Rated Storage Volume at or below 60 gallons: EF = 0.675 – (0.0012 x Rated Storage Volume in gallons)	For GSWHs with a Rated Storage Volume above 60 gallons: EF = 0.717 – (0.0019 x Rated Storage Volume in gallons)
	For ESWHs with a Rated Storage Volume at or below 80 gallons: EF = 0.965 – (0.0006 x Rated Storage Volume in gallons)	For ESWHs with a Rated Storage Volume above 80 gallons: EF = 1.051 – (0.00168 x Rated Storage Volume in gallons)
	For OSWHs (over the Entire Rated Storage Volume range): EF = 0.68 – (0.0019 x Rated Storage Volume in gallons)	
	For GIWHs (over the Entire Rated Storage Volume range): EF = 0.82 – (0.0019 x Rated Storage Volume in gallons)	
TSL 4	For GSWHs with a Rated Storage Volume at or below 60 gallons: EF = 0.675 – (0.0012 x Rated Storage Volume in gallons)	For GSWHs with a Rated Storage Volume above 60 gallons: EF = 0.717 – (0.0019 x Rated Storage Volume in gallons)
	For ESWHs with a Rated Storage Volume at or below 80 gallons: EF = 0.960 – (0.0003 x Rated Storage Volume in gallons)	For ESWHs with a Rated Storage Volume above 80 gallons: EF = 1.088 – (0.0019 x Rated Storage Volume in gallons)
	For OSWHs (over the Entire Rated Storage Volume range): EF = 0.68 – (0.0019 x Rated Storage Volume in gallons)	
	For GIWHs (over the Entire Rated Storage Volume range): EF = 0.82 – (0.0019 x Rated Storage Volume in gallons)	
TSL 5	For GSWHs with a Rated Storage Volume at or below 55 gallons: EF = 0.675 – (0.0015 x Rated Storage Volume in gallons)	For GSWHs with a Rated Storage Volume above 55 gallons: EF = 0.8012 – (0.00078 x Rated Storage Volume in gallons)

	For ESWHs with a Rated Storage Volume at or below 55 gallons: EF = 0.960 – (0.0003 x Rated Storage Volume in gallons)	For ESWHs with a Rated Storage Volume above 55 gallons: EF = 2.057 – (0.00113 x Rated Storage Volume in gallons)
	For OSWHs (over the Entire Rated Storage Volume range): EF = 0.68 – (0.0019 x Rated Storage Volume in gallons)	
	For GIWHs (over the Entire Rated Storage Volume range): EF = 0.82 – (0.0019 x Rated Storage Volume in gallons)	
TSL 6	For GSWHs with a Rated Storage Volume at or below 55 gallons: EF = 0.675 – (0.0012 x Rated Storage Volume in gallons)	For GSWHs with a Rated Storage Volume above 55 gallons: EF = 0.8012 – (0.00078 x Rated Storage Volume in gallons)
	For ESWHs with a Rated Storage Volume at or below 55 gallons: EF = 0.960 – (0.0003 x Rated Storage Volume in gallons)	For ESWHs with a Rated Storage Volume above 55 gallons: EF = 2.057 – (0.00113 x Rated Storage Volume in gallons)
	For OSWHs (over the Entire Rated Storage Volume range): EF = 0.68 – (0.0019 x Rated Storage Volume in gallons)	
	For GIWHs (over the Entire Rated Storage Volume range): EF = 0.82 – (0.0019 x Rated Storage Volume in gallons)	
TSL 7	For GSWHs with a Rated Storage Volume at or below 60 gallons: EF = 0.675 – (0.0012 x Rated Storage Volume in gallons)	For GSWHs with a Rated Storage Volume above 60 gallons: EF = 0.717 – (0.0019 x Rated Storage Volume in gallons)
	For ESWHs (over the Entire Rated Storage Volume range): EF = 2.057 – (0.00113 x Rated Storage Volume in gallons)	
	For OSWHs (over the Entire Rated Storage Volume range): EF = 0.68 – (0.0019 x Rated Storage Volume in gallons)	
	For GIWHs (over the Entire Rated Storage Volume range): EF = 0.82 – (0.0019 x Rated Storage Volume in gallons)	
TSL 8	For GSWHs (over the Entire Rated Storage Volume range): EF = 0.8012 – (0.00078 x Rated Storage Volume in gallons)	
	For ESWHs (over the Entire Rated Storage Volume range): EF = 2.406 – (0.00113 x Rated Storage Volume in gallons)	
	For OSWHs (over the Entire Rated Storage Volume range): EF = 0.74 – (0.0019 x Rated Storage Volume in gallons)	
	For GIWHs (over the Entire Rated Storage Volume range): EF = 0.95 – (0.0019 x Rated Storage Volume in gallons)	

Table 10.2.2 shows the TSLs DOE analyzed for direct heating equipment. TSL 1 consists of the efficiency levels that are close to the current shipment-weighted average efficiency. TSL 2, TSL 3 and TSL 4 consist of efficiency levels that have gradually higher efficiency than TSL 1. TSL 5 consists of the efficiency levels with electronic ignition and fan-assist (where applicable), and TSL 6 consists of the max-tech efficiency levels.

Table 10.2.2 Trial Standard Levels for Direct Heating Equipment*

Product Class	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
Gas Wall Fan (over 42,000 Btu/h)	75%	76%	77%	80%	75%	80%
Gas Wall Gravity (over 27,000 and up to 46,000 Btu/h)	66%	66%	71%	71%	72%	72%
Gas Floor (over 37,000 Btu/h)	58%	58%	58%	58%	58%	58%
Gas Room (over 27,000 and up to 46,000 Btu/h)	66%	67%	68%	68%	83%	83%
Gas Hearth (over 27,000 and up to 46,000 Btu/h)	67%	67%	67%	72%	72%	93%

* Expressed in AFUE.

Table 10.2.3 shows the TSLs DOE analyzed for pool heaters. TSL 1 consists of the efficiency level that is closest to the current shipment-weighted average efficiency. TSL 2 and TSL 3 consist of the efficiency level that has gradually higher efficiency than TSL 1. TSL 4 is the highest efficiency level with positive NPV. TSL 5 is the highest analyzed non-condensing efficiency level, and TSL 6 consists of the max-tech efficiency level.

Table 10.2.3 Trial Standard Levels for Pool Heaters*

Product Class	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
Gas	81%	82%	83%	84%	86%	95%

* Expressed in thermal efficiency.

10.3 FORECASTED ENERGY EFFICIENCIES

A key component of DOE's estimates of NES and NPV for each of the three heating products is the energy efficiencies forecasted for the base case (without new energy conservation standards) and each of the standards cases (with new energy conservation standards). The forecasted energy efficiency represents the annual shipments-weighted energy efficiency of the product under consideration during the forecast period (that is, from the assumed effective date of a new standard to 30 years after that date).

For calculating the NES, per-unit average annual energy consumption is a direct function of product energy efficiency. Chapter 7, Energy Use Characterization, describes how each product's per-unit energy consumption changes as a function of energy efficiency. For the NPV, the per-unit total installed cost is a direct function of energy efficiency; the per-unit annual operating cost, because it is a function of per-unit annual energy consumption, is indirectly dependent on product energy efficiency. Chapter 8, Life-Cycle Cost and Payback Period Analyses, describes how per-unit total installed costs change as a function of energy efficiency for each of the considered products. The above NES and NPV inputs, as well as all other inputs to the calculation of NES and NPV, are discussed further in sections 10.3 and 10.4.

To forecast base-case energy efficiencies for each product class, DOE used the shipments-weighted energy efficiency for 2013 for pool heaters and direct heating equipment and 2015 for water heaters as a starting point. To represent the distribution of product energy

efficiencies in 2013 or 2015, DOE used the same market shares as in the base case for the life-cycle cost (LCC) analysis (chapter 8).

To project trends until the end of the forecast period (2043 for direct heating equipment and pool heaters, and 2045 for water heaters), DOE examined the projected trend between the present and 2013 or 2015. For gas-fired storage water heaters and electric storage water heaters, DOE estimated the distribution of product energy efficiencies (EFs) in 2015 by accounting for the estimated market impact of the newly established ENERGY STAR efficiency levels for water heaters. As described in chapter 8, the result is that the market share of 0.80 EF gas-fired storage water heaters increases from zero at present to 1 percent in 2015, and the market share of heat pump electric storage water heaters increases from zero at present to 5 percent in 2015. DOE applied the projected rate of growth in efficiency between the present and 2015 to estimate the increase in average energy efficiency in each year until the end of the forecast period.

Because DOE found no quantifiable indications of change in energy efficiency in recent years for oil-fired storage and gas-fired instantaneous water heaters, direct heating equipment, and pool heaters, DOE estimated that the shipment-weighted energy efficiencies remain at the 2015 or 2013 level until the end of the forecast period in 2043 or 2045.

For its forecast of standards-case energy efficiencies, DOE used a “roll-up” scenario to establish the shipments-weighted average energy efficiency for the year that energy conservation standards are assumed to become effective (2013 and 2015). In this approach, product energy efficiencies in the base case that do not meet the standards level under consideration would “roll up” to meet the new standards level. Product energy efficiencies in the base case that exceeded the standard level under consideration would not be affected.

The following sections detail the forecasted energy efficiencies that DOE developed for each of the three types of heating products.

10.3.1 Water Heaters

Chapter 8 describes how DOE derived the market shares of various energy efficiencies in the base case for water heaters. Tables 10.3.1 through 10.3.4 show the base- and standards-case product energy efficiency distributions in 2015 that DOE used in its NIA for water heaters, as well as the shipments-weighted energy factor (SWEF) for the base case and each considered TSL.

Table 10.3.1 Gas-Fired Storage Water Heaters: Energy Efficiency Distributions in 2015

Energy Efficiency Level	EF	Market Shares								
		Base Case	TSL							
			1	2	3	4	5	6	7	8
Baseline	0.59	64%								
1	0.62	14%	78%				75%			
2	0.63	10%	10%	88%	88%	88%	10%	85%	88%	
3	0.64	6%	6%	6%	6%	6%	6%	6%	6%	
4	0.65	0%	0%	0%	0%	0%	0%	0%	0%	
5	0.67	5%	5%	5%	5%	5%	5%	5%	5%	
6	0.77	1%	1%	1%	1%	1%	4%	4%	1%	100%
SWEF (EF)		0.61	0.62	0.63	0.63	0.63	0.63	0.63	0.63	0.77

*Average efficiency weighted by the market share in shipments of the considered storage volume categories

Table 10.3.2 Electric Storage Water Heaters: Energy Efficiency Distributions in 2015

Energy Efficiency Level	EF	Market Shares								
		Base Case	TSL							
			1	2	3	4	5	6	7	8
Baseline	0.90	32%								
1	0.91	24%								
2	0.92	5%	61%							
3	0.93	23%	23%	83%						
4	0.94	7%	7%	7%	90%					
5	0.95	4%	4%	4%	4%	95%	89%	89%		
6	2.00	4%	4%	4%	4%	4%	10%	10%	99%	
7	2.35	1%	1%	1%	1%	1%	1%	1%	1%	100%
SWEF (EF)		0.98	0.98	0.99	1.00	1.01	1.07	1.07	2.00	2.35

*Average efficiency weighted by the market share in shipments of the considered storage volume categories

Table 10.3.3 Oil-Fired Storage Water Heaters: Energy Efficiency Distributions in 2015

Energy Efficiency Level	EF	Market Shares								
		Base Case	TSL							
			1	2	3	4	5	6	7	8
Baseline	0.53	0%								
1	0.54	24%								
2	0.56	0%								
3	0.58	23%	46%							
4	0.6	7%	7%	53%						
5	0.62	13%	13%	13%	67%	67%	67%	67%	67%	
6	0.66	17%	17%	17%	17%	17%	17%	17%	17%	
7	0.68	17%	17%	17%	17%	17%	17%	17%	17%	100%
SWEF (EF)		0.61	0.62	0.63	0.64	0.64	0.64	0.64	0.64	0.68

Table 10.3.4 Gas-Fired Instantaneous Water Heaters: Energy Efficiency Distributions in 2015

Energy Efficiency Level	EF	Market Shares								
		Base Case	TSL							
			1	2	3	4	5	6	7	8
Baseline	0.62	1%								
1	0.69	3%								
2	0.78	1%								
3	0.8	5%								
4	0.82	52%	61%	61%	61%	61%	61%	61%	61%	
5	0.84	2%	2%	2%	2%	2%	2%	2%	2%	
6	0.85	4%	4%	4%	4%	4%	4%	4%	4%	
7	0.92	20%	20%	20%	20%	20%	20%	20%	20%	
8	0.95	12%	12%	12%	12%	12%	12%	12%	12%	100%
SWEF (EF)		0.85	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.95

10.3.2 Direct Heating Equipment

Chapter 8 describes how DOE derived the market shares of various energy efficiencies in the base case for direct heating equipment. Tables 10.3.5 through 10.3.9 show the distributions for base- and standards-case product energy efficiency that DOE used in its NIA for direct heating equipment. Also included in the tables are the shipments-weighted energy efficiencies associated with the base case and each considered TSL.

Table 10.3.5 Gas Wall Fan Direct Heating Equipment: Energy Efficiency Distributions in 2013

Energy efficiency Level	AFUE (%)	Market Shares						
		Base Case	TSL					
			1	2	3	4	5	6
Baseline	74	40%						
1	75	7%	47%				47%	
2	76	27%	27%	74%			27%	
3	77	19%	19%	19%	93%		19%	
4	80	7%	7%	7%	7%	100%	7%	100%
SWAFUE (AFUE)		75.6	76.0	76.5	77.2	80.0	76.0	80.0

* Annual fuel utilization efficiency

Table 10.3.6 Gas Wall Gravity Direct Heating Equipment: Energy Efficiency Distributions in 2013

Energy efficiency Level	AFUE (%)	Market Shares						
		Base Case	TSL					
			1	2	3	4	5	6
Baseline	64	25%						
1	66	25%	50%	50%				
2	68	13%	13%	13%				
3	69	37%	37%	37%	100%	100%		
4	70	0%	0%	0%	0%	0%	100%	100%
SWAFUE (AFUE)		66.9	67.4	67.4	69.0	69.0	70.0	70.0

Table 10.3.7 Gas Floor Direct Heating Equipment: Energy Efficiency Distributions in 2013

Energy efficiency Level	AFUE (%)	Market Shares						
		Base Case	TSL					
			1	2	3	4	5	6
Baseline	57	42%						
1	58	58%	100%	100%	100%	100%	100%	100%
SWAFUE (AFUE)		57.6	58.0	58.0	58.0	58.0	58.0	58.0

Table 10.3.8 Gas Room Direct Heating Equipment: Energy Efficiency Distributions in 2013

Energy efficiency Level	AFUE (%)	Market Shares						
		Base Case	TSL					
			1	2	3	4	5	6
Baseline	64	26%						
1	65	0%						
2	66	25%	50%					
3	67	25%	25%	75%				
4	68	25%	25%	25%	100%	100%		
5	83	0%	0%	0%	0%	0%	100%	100%
SWAFUE (AFUE)		66.2	66.7	67.2	68.0	68.0	83.0	83.0

Table 10.3.9 Gas Hearth Direct Heating Equipment: Energy Efficiency Distributions in 2013

Energy efficiency Level	AFUE (%)	Market Shares						
		Base Case	TSL					
			1	2	3	4	5	6
Baseline	64	39%						
1	67	38%	77%	77%	77%			
2	72	23%	23%	23%	23%	99%	99%	
3	93	1%	1%	1%	1%	1%	1%	100%
SWAFUE (AFUE)		67.1	68.3	68.3	68.3	72.1	72.1	93.0

10.3.3 Pool Heaters

Chapter 8 describes how DOE derived the market shares of various energy efficiencies in the base case for pool heaters. Table 10.3.10 shows the distributions for the base- and standards-case product energy efficiency that DOE used in its NIA for pool heaters. Also included in the table is the shipments-weighted thermal efficiency (SWTE) associated with the base case and each considered standard efficiency level.

Table 10.3.10 Pool Heaters: Energy Efficiency Distributions in 2013

Energy Efficiency Level	Thermal Efficiency	Market Shares						
		Base Case	TSL					
			1	2	3	4	5	6
Baseline	78%	2%						
1	79%	27%						
2	81%	21%	49%					
3	82%	28%	28%	77%				
4	83%	2%	2%	2%	79%			
5	84%	12%	12%	12%	12%	91%		
6	86%	8%	8%	8%	8%	8%	99%	
7	90%	0%	0%	0%	0%	0%	0%	
8	95%	1%	1%	1%	1%	1%	1%	100%
Sales-Weighted Thermal Efficiency		0.82	0.82	0.83	0.83	0.84	0.86	0.95

10.4 NATIONAL ENERGY SAVINGS

The following sections discuss the definition of NES and the inputs to calculations of NES.

10.4.1 Definition of National Energy Savings

DOE calculates NES for each year as the difference between energy consumption of the product stock using the average unit energy consumption (UEC) of the stock in the base case (without new standards) or in a case given new standards.

$$NES(y)_{class} = AffStock(y)_{class} \times \left(UEC(y)_{base,class} - UEC(y)_{std,class}\right)$$

Where:

$AffStock(y)_{class}$ = the stock of equipment sold after the year of the standard that is still in operation in year y (affected stock),
$UEC(y)_{base\ class}$ = the unit energy consumption in the base case in year y, and
$UEC(y)_{std.\ class}$ = the unit energy consumption in the standard case in year y.

The affected stock in year y is given by:

$$AffStock(y)_{class} = \sum_{i=stdyr}^{y} S(i)_{class} \times Surv(y-i)_{class}$$

The quantity of stock in year *y* is dependent on the number of shipments $S(y)_{\text{class}}$ in past years, multiplied by the survival function *Surv(v)*, which is the fraction of shipments that survive until age *v* (vintage). Only those shipments made after the year standards are enacted (*stdyr*) are considered in calculating NES, because shipments before that date are unaffected by the standard, and thus will produce no savings. The variables $UEC_{base,class}$ and $UEC_{std,class}$ are the average unit energy consumption of products sold in either the base or standards case. In the case of gas-fired and electric storage water heaters, the average unit energy consumption changes over time. For all other product classes, unit energy consumption remains constant.

Cumulative energy savings are the sum of annual NES during a defined period, which for water heaters is 2015–2045 and for the other products considered is 2013–2043:

$$NES_{cum} = \sum_{y=stdyr}^{2043} NES(y)$$

The stock of products is dependent on annual shipments and the lifetime of the products.

10.4.2 Inputs to National Energy Savings

The inputs for determining NES are:

- annual energy consumption per unit (*UEC)*
- shipments
- equipment stock ($STOCK_V$)
- national annual energy consumption (AEC)
- site-to-source conversion factor (*src_conv)*

10.4.2.1 Annual Energy Consumption per Unit

DOE developed per-unit annual energy consumption as a function of product energy efficiency for each of the considered products (see chapter 7). DOE used the shipments-weighted energy efficiencies for the base and standards cases (presented in section 10.2), along with the data on annual energy use by efficiency level presented in chapter 8, to estimate the shipments-weighted average annual per-unit energy consumption under the base and standards cases.

Water Heaters. Using the relationship between water heater EF and annual energy consumption described in chapter 8, DOE calculated the per-unit annual energy consumption based on the average energy efficiencies that correspond to the base case and each considered standard case for each water heater product class (Table 10.4.1).

Table 10.4.1 Water Heaters: Shipments-Weighted Average Annual Energy Consumption in 2015

Product Class		Base Case	TSL							
			1	2	3	4	5	6	7	8
GSWH	EF	0.59	0.62	0.63	0.63	0.63	0.62	0.63	0.63	0.77
	Annual Energy Use (MMBtu/yr)	16.1	15.6	15.3	15.3	15.3	15.5	15.2	15.3	12.6
ESWH	EF	0.90	0.92	0.93	0.94	0.95	1.07	1.07	2.00	2.35
	Annual Energy Use (kWh/yr)	2502	2475	2464	2428	2399	2335	2335	1518	1355
OSWH	EF	0.53	0.58	0.60	0.62	0.62	0.62	0.62	0.62	0.68
	Annual Energy Use (MMBtu/yr)	18.8	18.4	18.1	17.7	17.7	17.7	17.7	17.7	16.6
GIWH	EF	0.62	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.95
	Annual Energy Use (MMBtu/yr)	11.4	11.2	11.2	11.2	11.2	11.2	11.2	11.2	10.3

When calculating energy consumption for water heaters at each considered efficiency level above the baseline, DOE applied a rebound effect of 10 percent. When the rebound effect is incorporated, calculated energy savings are lower than if no rebound effect were considered.

As noted in section 10.2, DOE projected trends in average energy efficiency of water heaters in the base case and standards cases. Because it is a function of energy efficiency, the per-unit annual energy consumption mirrors the trends in energy efficiency (Figures 10.4.1 through 10.4.2).

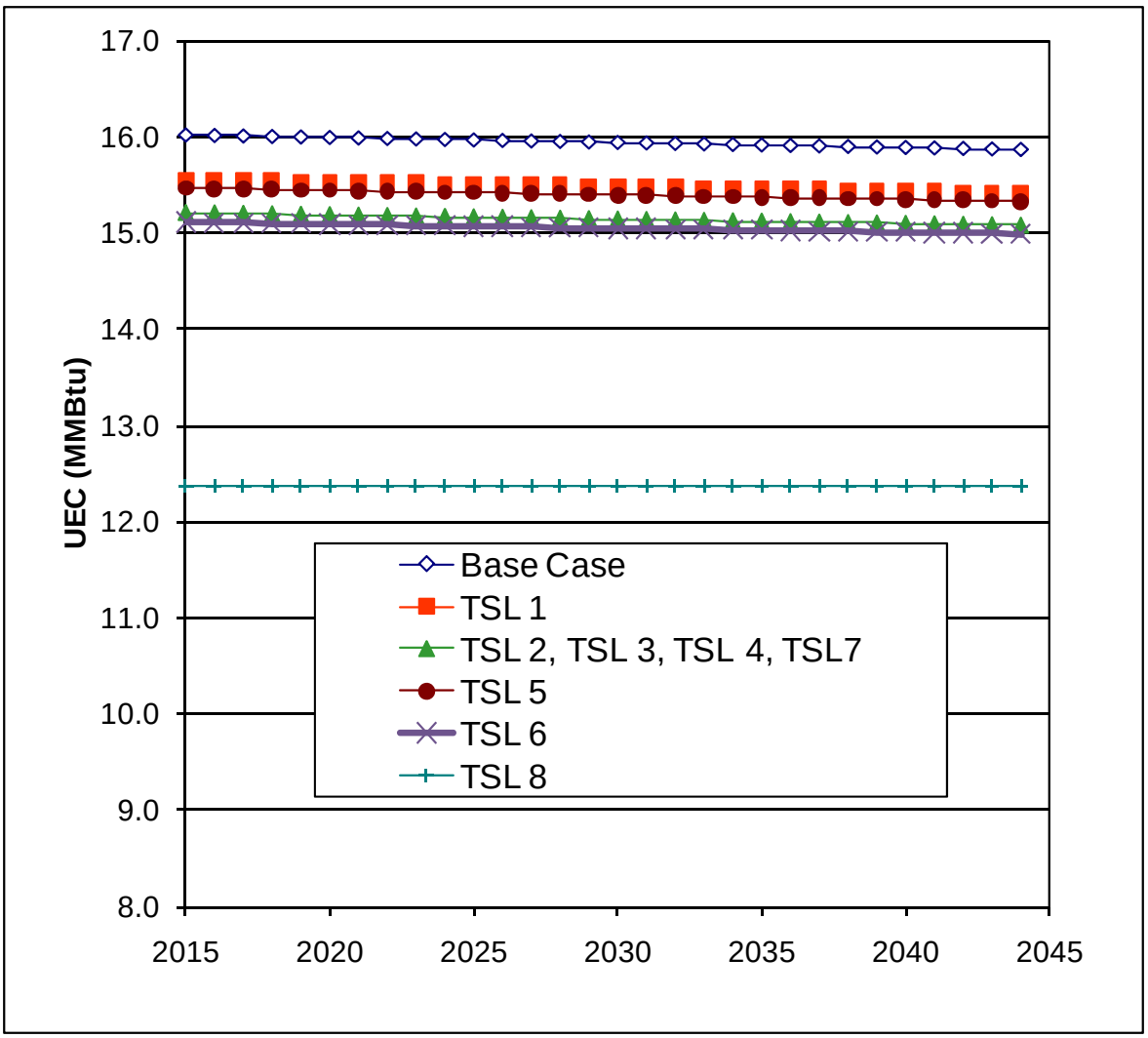

Figure 10.4.1 Gas-Fired Storage Water Heaters: Forecasted Trends in Average Annual Energy Use

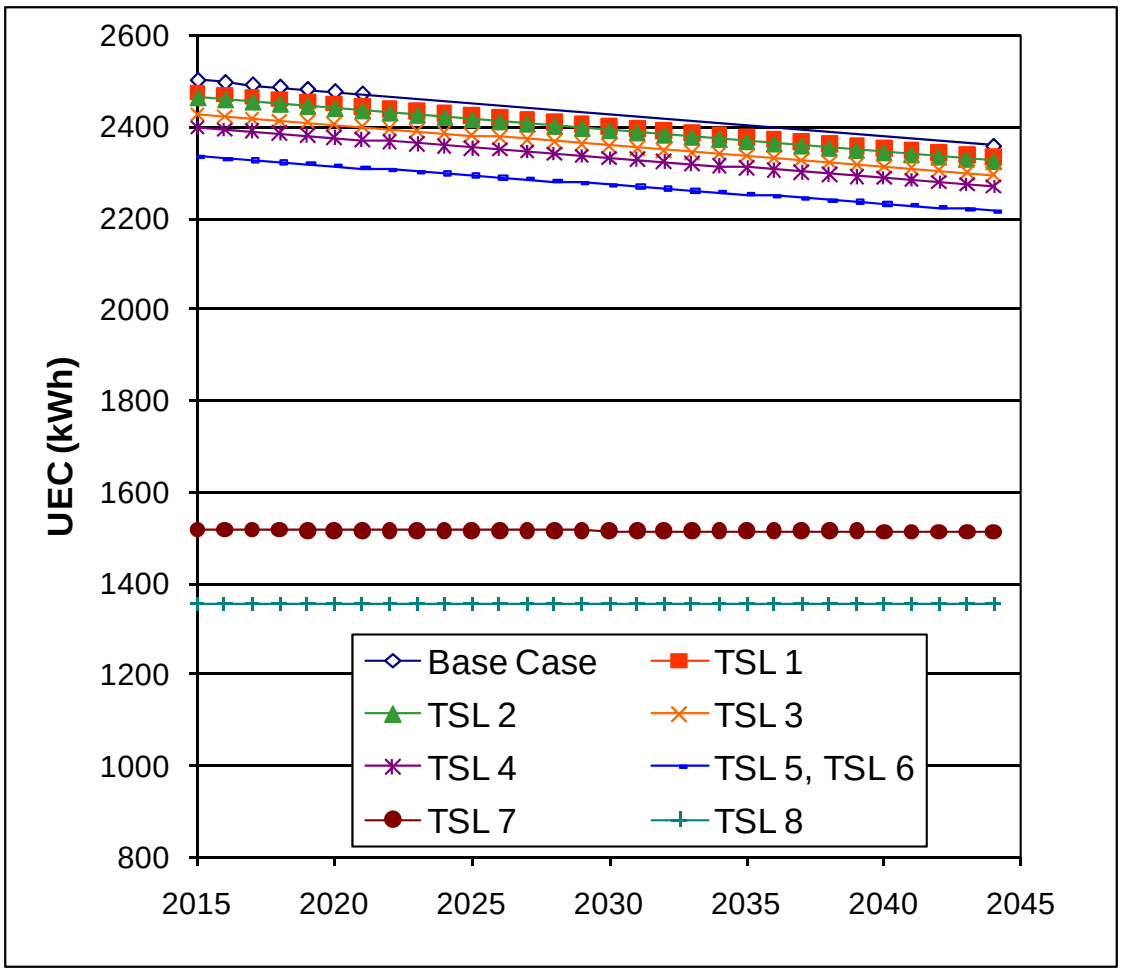

Figure 10.4.2 Electric Storage Water Heaters: Forecasted Trends in Average Annual Energy Use

Direct Heating Equipment. Using the relationship between the AFUE of each direct heating equipment product and the annual energy consumption described in chapter 8, DOE calculated the average annual energy consumption of direct heating equipment products at each considered efficiency level (Table 10.4.2). The calculation was based on the shipments-weighted energy efficiencies that correspond to the base case and each standards case for the four product classes of direct heating equipment.

Table 10.4.2 Direct Heating Equipment: Shipments-Weighted Average Annual Energy Consumption (MMBtu/yr)

Product Class	Base Case	TSL					
		1	2	3	4	5	6
Gas Wall Fan DHE	28.6	28.0	27.8	27.5	26.5	28.0	26.5
Gas Wall Gravity DHE	28.7	28.5	28.5	27.8	27.8	26.5	26.5
Gas Floor DHE	20.8	20.5	20.3	20.1	19.0	19.0	19.0
Gas Room DHE	30.5	30.3	30.3	30.3	30.3	30.3	30.3
Gas Hearth DHE	15.2	14.4	14.4	14.4	13.6	13.6	10.6

When calculating energy consumption at each considered efficiency level for each direct heating equipment product, DOE applied a rebound effect of 15 percent.

As noted in section 10.2, DOE assumed that forecasted energy efficiencies in the base and standards cases remain frozen at 2013 levels. Because per-unit annual energy consumption is a function of energy efficiency, DOE held the values shown in Table 10.4.2 constant throughout the forecast period.

Pool Heaters. DOE used the relationship between pool heater energy efficiency and annual energy consumption described in chapter 8 to calculate average annual gas consumption for pool heaters at each considered efficiency level (Table 10.4.3). The calculations were based on the shipments-weighted energy efficiencies that correspond to the base case and each considered efficiency.

Table 10.4.3 Pool Heaters: Shipments-Weighted Average Annual Energy Consumption

	Base Case	TSL					
		1	2	3	4	5	6
Annual Energy Use (MMBtu/yr)	32.7	32.5	32.5	32.3	31.8	31.6	31.0

When calculating energy consumption at each considered efficiency level for each pool heater, DOE applied a rebound effect of 10 percent. When the rebound effect is incorporated, calculated energy use is higher than if no rebound effect were considered.

As noted in section 10.2, DOE assumed that forecasted energy efficiencies in the base and standards cases remain at 2013 levels. Because per-unit annual energy consumption is a function of energy efficiency, DOE held the values shown in Table 10.4.3 constant throughout the forecast period.

10.4.2.2 Shipments and Equipment Stock

The methodology for conducting and generating shipments forecasts for each considered product is described in detail in chapter 9. The product stock in a given year is the number of products shipped from earlier years that survive in the given year. The NIA models keep track of the number of units shipped each year. DOE assumes that the products have an increasing

probability of retiring as they age. The survival function represents the probability of survival as a function of years since purchase. The sections in chapter 9 that concern with specific products present further details on the survival functions that DOE used in its analyses.

10.4.2.3 National Annual Energy Consumption

The national annual energy consumption (AEC), which is calculated for the base case only, is the product of the annual energy consumption per unit and the number of units of each vintage.

$$AEC(y)_{class} = UEC_{base,class} \times Stock(y)_{class}$$

Where:

$UEC_{base\ class}$ = the unit energy consumption in the base case, and
$Stock(y)_{class}$ = the stock of equipment in year *y*.

10.4.2.4 Site-to-Source Energy Conversion Factors

In determining annual NES, DOE initially considered the annual energy consumption at a residence site. DOE then calculated primary (source) energy savings from site energy consumption by applying a conversion factor to account for losses associated with the generation, transmission, and distribution of electricity and natural gas. The site-to-source conversion factor is a multiplicative factor used for converting site energy consumption into primary or source energy consumption, expressed in quadrillion Btu (quads).

DOE used annual site-to-source conversion factors based on the version of the National Energy Modeling System (NEMS)[a] that corresponds to the DOE Energy Information Administration's (EIA's) *Annual Energy Outlook 2010* (AEO 2010).[1] The factors that DOE developed are marginal values, which represent the response of the system to an incremental decrease in consumption. Natural gas losses include pipeline leakage, pumping energy, and transportation fuel. For electricity, the conversion factors change over time in response to projected changes in generation sources (*i.e.*, the types of power plant projected to provide electricity).

Figure 10.4.3 shows the site-to-source conversion factors for electricity between 2005 and 2035. NEMS outputs stop in 2035; DOE assumed that conversion factors remain constant at 2035 values throughout the rest of the forecast. The conversion factor for natural gas increases slightly from 1.075 Btu in 2005 to 1.092 Btu in 2030.

[a] Chapter 13, Utility Impact Analysis, provides more detail on NEMS.

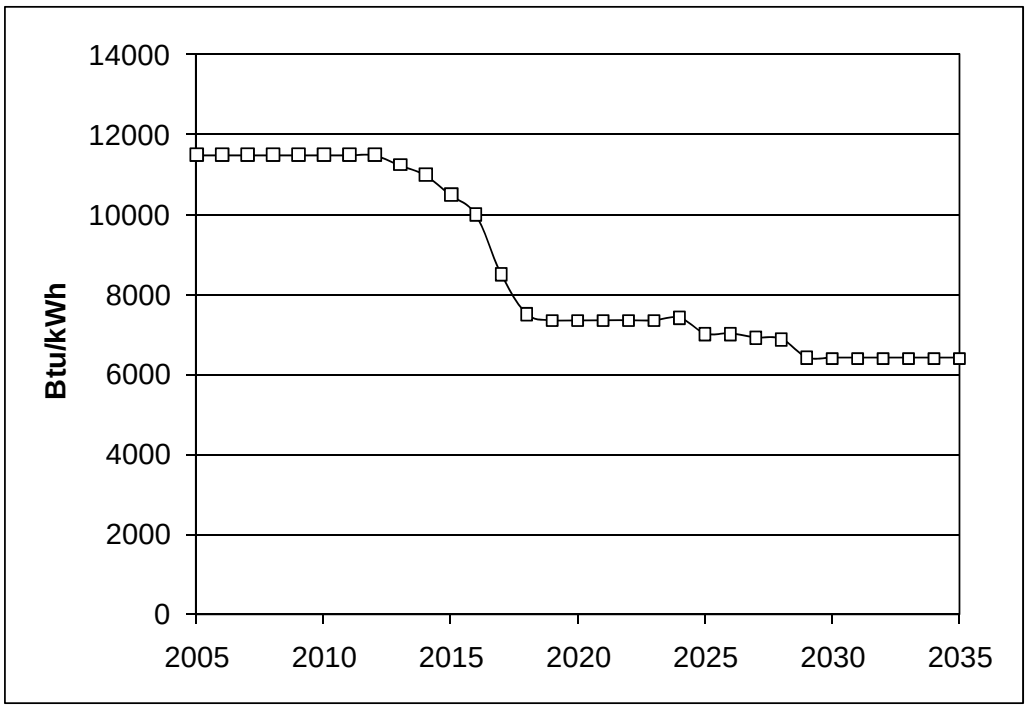

Figure 10.4.3 Site-to-Source Conversion Factors for Electricity

10.5 CONSUMER NET PRESENT VALUE

The following sections provide the definition of the consumer NPV and inputs to the calculation of NPV.

10.5.1 Definition of Net Present Value

The consumer NPV is the value in the present of the costs and savings experienced by consumers of the considered products. The NPV is described by the equation:

$$NPV = \sum_{y} \big(S(y) - C(y)\big) \times DF(y)$$

Where:

S(y) = value of operating cost savings (including energy, repair, and maintenance costs) in year *y*,
C(y) = value of increased total installed costs (including products and installation), and
DF(y) = discount factor in each year.

DOE calculated the total annual savings in operating costs by multiplying the number or stock of a given product (by vintage) by its per-unit savings on operating costs (also by vintage).

DOE calculated the total annual increases in installed costs by multiplying the number or stock of the given product (by vintage) by its per-unit total increase in installed costs (also by vintage). The calculation of the annual savings in operating costs and total annual increases in installed cost is represented by the following equations.

$$OCS(y) = \sum UOCS(y) \times AffStock(y)$$

$$TIC\ (y) = \sum UTIC(y) xS(y)$$

Where:

OCS =	total annual savings in operating costs each year summed over vintages of the product stock considered, *AffStock(y)*,
TIC =	total annual increase in installed cost each year summed over vintages of the product stock considered, *AffStock(y)*,
S(y)=	stock of product (millions of units) of vintage *V* that survive in the year for which DOE calculated annual energy consumption,
UOCS(y) =	annual savings in operating cost per unit in year *y*,
UTIC(y) =	annual increase in total installed cost per unit in year *y*, and
y =	year in forecast.

DOE calculated a discount factor from the discount rate and the number of years between the present (*i.e.*, the year to which the sum is being discounted) and the year in which the costs and savings occur. The NPV is the sum over time of the discounted net savings.

10.5.2 Inputs to Calculation of Net Present Value

The inputs to calculations of the consumer NPV are:

- total installed cost per unit,
- annual savings in operating cost per unit,
- total annual increases in installed cost,
- total annual operating costs,
- discount factor,
- present value of costs, and
- present value of savings.

The increase in total annual installed cost is equal to the annual change in the per-unit total installed cost (difference between base case and standards cases) multiplied by the shipments forecasted for the standards case. As when calculating the NES, DOE did not use base case shipments to calculate total annual installed costs for all of the products.

The total annual savings in operating costs are equal to the change in annual operating costs (difference between base case and standards case) per unit multiplied by the shipments

forecasted in the standards case. The annual operating cost includes energy, repair, and maintenance costs, as described in chapter 8, Life-Cycle Cost and Payback Period Analyses.

10.5.2.1 Total Installed Cost per Unit

The per-unit total installed cost of each considered product is described in chapter 8 as a function of product energy efficiency. Because the per-unit total installed cost is directly dependent on energy efficiency, DOE used the shipments-weighted energy efficiencies of the base and standards cases described in section 10.2, in combination with the total installed costs developed in chapter 8, to estimate the shipments-weighted average per-unit total installed cost under the base and standards cases. The changes over the forecast period that apply to the shipments-weighted efficiency also apply to the total installed costs.

Water Heaters. DOE based average water heater prices on average manufacturer costs plus average overall markup values. Using the relationship, presented in chapter 8, between water heater EF and total installed cost, DOE derived the per-unit total installed cost based on the shipments-weighted energy efficiencies that correspond to the base case and each standards case for the four water heater product classes being considered (Table 10.5.1). For gas and electric storage water heaters, EF increases over time in the base case, so per-unit total installed cost increases as well.

Table 10.5.1 Water Heaters: Shipments-Weighted Average Total Installed Cost in 2015 (2009$)

Product Class	Base Case	TSL							
		1	2	3	4	5	6	7	8
Gas Storage	$1,176	$1,235	$1,292	$1,292	$1,292	$1,253	$1,310	$1,292	$1,893
Electric Storage	$661	$683	$690	$724	$757	$806	$806	$1,576	$1,703
Oil Storage	$2,070	$2,079	$2,073	$2,087	$2,087	$2,087	$2,087	$2,087	$2,180
GIWH	$2,584	$2,612	$2,612	$2,612	$2,612	$2,612	$2,612	$2,612	$3,097

Direct Heating Equipment. Total installed cost for direct heating equipment includes costs for both the product and the installation. DOE based average product prices on average manufacturer costs multiplied by average overall markup values. Using the relationship between the annual fuel utilization efficiency (AFUE) for direct heating equipment and total installed cost presented in chapter 8, DOE calculated the per-unit total installed cost for direct heating equipment products, based on the shipments-weighted energy efficiencies that correspond to the base case and each standards case (Table 10.5.2).

Table 10.5.2 Direct Heating Equipment: Shipments-Weighted Average Total Installed Costs (2009$)

Product Class	Base Case	TSL					
		1	2	3	4	5	6
Gas Wall Fan DHE	$1,906	$1,929	$1,941	$1,974	$ 2,200	$1,929	$2,200
Gas Wall Gravity DHE	$1,526	$1,541	$1,541	$1,609	$ 1,609	$1,924	$1,924
Gas Floor DHE	$1,487	$1,525	$1,553	$1,584	$ 1,845	$1,845	$1,845
Gas Room DHE	$2,241	$2,263	$2,263	$2,263	$ 2,263	$2,263	$2,263
Gas Hearth DHE	$1,747	$1,779	$1,779	$1,779	$ 2,078	$2,078	$2,867

Pool Heaters. The total installed cost of pool heaters includes the cost of both the product and the installation. DOE based average product prices on average manufacturer costs multiplied by average overall markup values. Using the relationship between pool heater efficiency and total installed cost presented in chapter 8, DOE calculated the per-unit total installed cost based on the shipments-weighted energy efficiencies that correspond to the base case and each standards case (Table 10.5.3).

Table 10.5.3 Pool Heaters: Shipments-Weighted Average Total Installed Costs(2009$)

Base Case	TSL					
	1	2	3	4	5	6
$3426	$3434	$3462	$3570	$3658	$4160	$5283

10.5.2.2 Annual Operating Cost Savings per Unit

Per-unit annual operating cost includes costs for energy, repair, and maintenance. DOE determined the savings in per-unit annual operating cost for each product by multiplying the savings in per-unit annual energy consumption by the appropriate energy price for each year of the forecast period.

Estimates of average annual energy consumption for the base case and each standards case were presented in section 10.3.2.1. The energy prices and price trends (based on *AEO2010* Reference case) are described in chapter 8.

10.5.2.3 Total Increases in Annual Installed Cost

The increase in total annual installed cost for any given standards case is the product of the total installed cost increase per unit due to the standard and the number of units of each vintage. This approach accounts for differences in total installed cost from year to year. DOE used the following equation (also presented in section 10.4.1) to determine the increase in total annual installed cost for a given standards case.

$$TIC\ (y) = \sum UTIC(y) \times S(y)$$

10.5.2.4 Total Savings in Annual Operating Cost

The total savings in annual operating cost for any given standards case is the product of the annual operating cost savings per unit due to the standard and the number of units of each vintage. This approach accounts for differences in savings in annual operating cost from year to year. DOE used the following equation (also presented in section 10.4.1) to determine the total savings in annual operating cost for a given standards case.

$$OCS(y) = \sum UOCS(y) \times AffStock(y)$$

As discussed in chapter 8, the take-back in energy consumption associated with the rebound effect provides increased value to consumers (*e.g.*, more hot water use). The net impact is the sum of the change in the cost of owning the heating product (that is, national consumer expenditures for total installed and operating costs) and the increased value of the enhanced service from the product. DOE believes that, if the increased national value (to consumers) produced by the rebound effect could be monetized, it would be similar to the monetary value of the foregone energy savings. For this analysis, DOE estimated that this increased value to consumers is equivalent to the monetary value of the energy savings that would have occurred without the rebound effect. Therefore, the national economic impacts on consumers with or without the rebound effect, as measured by the NPV analysis, are the same.

10.5.2.5 Discount Factor

DOE multiplies monetary values in future years by a discount factor to determine present values. The discount factor (*DF*) is described by the equation:

$$DF = \frac{1}{(1+r)^{(y-y_p)}}$$

Where:

r = discount rate,
y = year of the monetary value, and
y_P = year in which the present value is being determined.

DOE used both a 3-percent and a 7-percent real discount rate when estimating national impacts. These discount rates were applied in accordance with the Office of Management and Budget (OMB)'s guidance to Federal agencies on developing regulatory analyses (OMB Circular A-4, September 17, 2003, and section E., "Identifying and Measuring Benefits and Costs," therein). DOE defines the present year as 2010 because the final rule for this rulemaking will be published in 2010.

10.5.2.6 Present Value of Costs

The present value of increased installed costs is the annual increase in installed cost for each year (i.e., the difference between the standards case and base case), discounted to the present and summed over the period for which DOE is considering the installed products (from the effective date of energy conservation standards through 30 years later).

The increase in total installed cost refers to both product and installation costs associated with the higher energy efficiency of products purchased in the standards case compared to the base case. DOE calculated annual increases in installed cost as the difference in total cost of new products installed each year, multiplied by the shipments in the standards case.

10.5.2.7 Present Value of Savings

The present value of savings in operating cost is the annual savings in operating cost (i.e., the difference between the base case and standards case), discounted to the present and summed over the period that begins with the effective date of standards and ends when the last installed unit is retired from service.

Savings represent decreases in operating cost (including costs for energy, repair, and maintenance) associated with the higher energy efficiency of products purchased in a standards case compared to the base case. Total annual savings in operating cost are the savings per unit multiplied by the number of units of each vintage that survive in a particular year. Because equipment consumes energy throughout its lifetime, the energy consumption for units installed in the past year includes energy consumed until the unit is retired from service.

10.6 RESULTS

The NIA model provides estimates of the NES and NPV produced by various efficiency levels. The inputs to the NIA model were discussed in sections 10.3.2 (NES Inputs) and 10.4.2 (NPV Inputs). DOE generated the NES and NPV results using a Microsoft Excel spreadsheet, which is accessible on the Internet (www.eere.energy.gov/buildings/appliance_standards/). Details and instructions for using the spreadsheet are provided in appendix 9-A, User Instructions for Shipments and National Energy Savings Spreadsheet Model, in the section titled, “NES and NPV input summary.”

Table 10.6.1 summarizes inputs to the NIA model.

Table 10.6.1 Inputs to National Energy Savings and Net Present Value

Input	Data Description
Shipments	Annual shipments from shipments model (see chapter 9).
Effective Date of Standard	2015 for water heaters, 2013 for pool heaters and DHE
Energy Efficiencies Forecasted for Base Case	Shipments-weighted unit energy consumption (UEC) determined for each year.
Energy Efficiencies in Standards Cases	"Roll-up" scenario assumed for determining shipments-weighted UEC for each standards case (see section 10.2.).
Annual Energy Consumption per Unit	Annual weighted-average values are a function of shipments-weighted UEC.
Total Installed Cost per Unit	Annual weighted-average values are a function of efficiency level.
Energy Cost per Unit	Annual weighted-average values are a function of the annual UEC and energy prices (see chapter 8 for energy prices).
Repair Cost and Maintenance Cost per Unit	Annual values are a function of efficiency level (see chapter 8).
Escalation of Energy Prices	Based on EIA AEO 2010 forecasts (to 2035) and on extrapolation to 2045 (see chapter 8).
Energy Site-to-Source Conversion Factor	Conversion, which differs yearly, is generated by DOE/EIA's NEMS program (a time-series conversion factor that includes electric generation, transmission, and distribution losses).
Discount Rate	3 percent and 7 percent real.
Present Year	Future expenses are discounted to 2010.

The results reported in this chapter are based on energy price forecasts and housing starts forecasts from the *AEO2010* Reference case. Appendix 9-C presents results based on inputs from the *AEO2010* Low Economic Growth and High Economic Growth cases. These cases have higher and lower energy price trends compared to the Reference case, as well as higher and lower housing starts, which results in higher and lower appliance shipments to new homes.

10.6.2 National Energy Savings Results

The following sections provide results of calculating NES for the TSLs analyzed for each of the three heating products. NES results, which are cumulative over the forecast period, are in primary energy savings. Because DOE based the inputs to the NIA model on weighted-average values, results are discrete point values, rather than a distribution of values as produced by the LCC and PBP analyses. DOE reports both undiscounted and discounted values of energy savings. Discounted energy savings represent a policy perspective where energy savings farther in the future are less significant than energy savings closer to the present

10.6.2.1 Water Heaters

Tables 10.6.2 through 10.6.4 show the NES results for the TSLs analyzed for water heaters.

Table 10.6.2 Water Heaters: Cumulative National Energy Savings in Quads

Product Class	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6	TSL 7	TSL 8
Gas-Fired Storage	0.69	1.17	1.17	1.17	0.81	1.29	1.17	4.91
Electric Storage	0.29	0.41	0.79	1.09	1.67	1.67	8.90	11.22
Oil-Fired Storage	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Gas-Fired Instantaneous	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.58
TOTAL	1.07	1.66	2.05	2.35	2.58	3.06	10.16	16.73

Table 10.6.3 Water Heaters: Cumulative National Energy Savings in Quads, Discounted at 3 Percent

Product Class	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6	TSL 7	TSL 8
Gas-Fired Storage	0.36	0.62	0.62	0.62	0.43	0.68	0.62	2.59
Electric Storage	0.15	0.22	0.42	0.58	0.90	0.90	4.74	6.02
Oil-Fired Storage	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Gas-Fired Instantaneous	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.30
TOTAL	0.56	0.88	1.09	1.25	1.38	1.63	5.40	8.92

Table 10.6.4 Water Heaters: Cumulative National Energy Savings in Quads, Discounted at 7 Percent

Product Class	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6	TSL 7	TSL 8
Gas-Fired Storage	0.17	0.29	0.29	0.29	0.20	0.32	0.29	1.22
Electric Storage	0.07	0.11	0.20	0.28	0.43	0.43	2.31	2.91
Oil-Fired Storage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Gas-Fired Instantaneous	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.14
TOTAL	0.27	0.42	0.52	0.60	0.66	0.78	2.63	4.28

10.6.2.2 Direct Heating Equipment

Tables 10.6.5 through 10.6.7 show the NES results for the TSLs analyzed for direct heating equipment.

Table 10.6.5 Direct Heating Equipment: Cumulative National Energy Savings in Quads

Product Class	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
Gas Wall Fan	0.01	0.01	0.01	0.03	0.01	0.03
Gas Wall Gravity	0.01	0.01	0.03	0.03	0.06	0.06
Gas Floor	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Gas Room	0.001	0.002	0.004	0.004	0.036	0.036
Gas Hearth	0.19	0.19	0.19	0.37	0.37	1.13
TOTAL	0.20	0.21	0.23	0.43	0.48	1.26

Table 10.6.6 Direct Heating Equipment: Cumulative National Energy Savings in Quads, Discounted at 3 Percent

Product Class	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
Gas Wall Fan	0.00	0.01	0.01	0.01	0.00	0.01
Gas Wall Gravity	0.00	0.00	0.01	0.01	0.04	0.04
Gas Floor	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Gas Room	0.001	0.001	0.002	0.002	0.020	0.020
Gas Hearth	0.11	0.11	0.11	0.21	0.21	0.64
TOTAL	0.11	0.12	0.13	0.24	0.27	0.71

Table 10.6.7 Direct Heating Equipment: Cumulative National Energy Savings in Quads, Discounted at 7 Percent

Product Class	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
Gas Wall Fan	0.00	0.00	0.00	0.01	0.00	0.01
Gas Wall Gravity	0.00	0.00	0.01	0.01	0.02	0.02
Gas Floor	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Gas Room	0.000	0.001	0.001	0.001	0.010	0.010
Gas Hearth	0.05	0.05	0.05	0.11	0.11	0.33
TOTAL	0.06	0.06	0.07	0.12	0.14	0.37

10.6.2.3 Pool Heaters

Table 10.6.8 shows the NES results for the TSLs analyzed for pool heaters.

Table 10.6.8 Pool Heaters: Cumulative National Energy Savings in Quads

	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
Not Discounted	0.01	0.02	0.04	0.06	0.09	0.22
Discounted at 3 %	0.01	0.01	0.02	0.03	0.05	0.12
Discounted at 7 %	0.00	0.01	0.01	0.02	0.03	0.06

10.6.3 Annual Costs and Savings

Figure 10.6.1 illustrates the basic inputs to calculations of the NPV for the example of the non-discounted annual increases in installed cost and annual savings in operating cost for gas-fired storage water heaters under TSL 4. The figure also shows net savings, which is the

difference between the savings and costs for each year. The annual product cost is the sum of the increase in the total installed cost for products purchased each year during the forecast period. The annual savings in operating cost is the savings for products operating in each year. (Incremental repair and maintenance costs are zero for this efficiency level.) The NPV is the difference between the cumulative annual discounted savings and the cumulative annual discounted costs. Figures similar to the one presented below could be created for each of the considered products' standard cases.

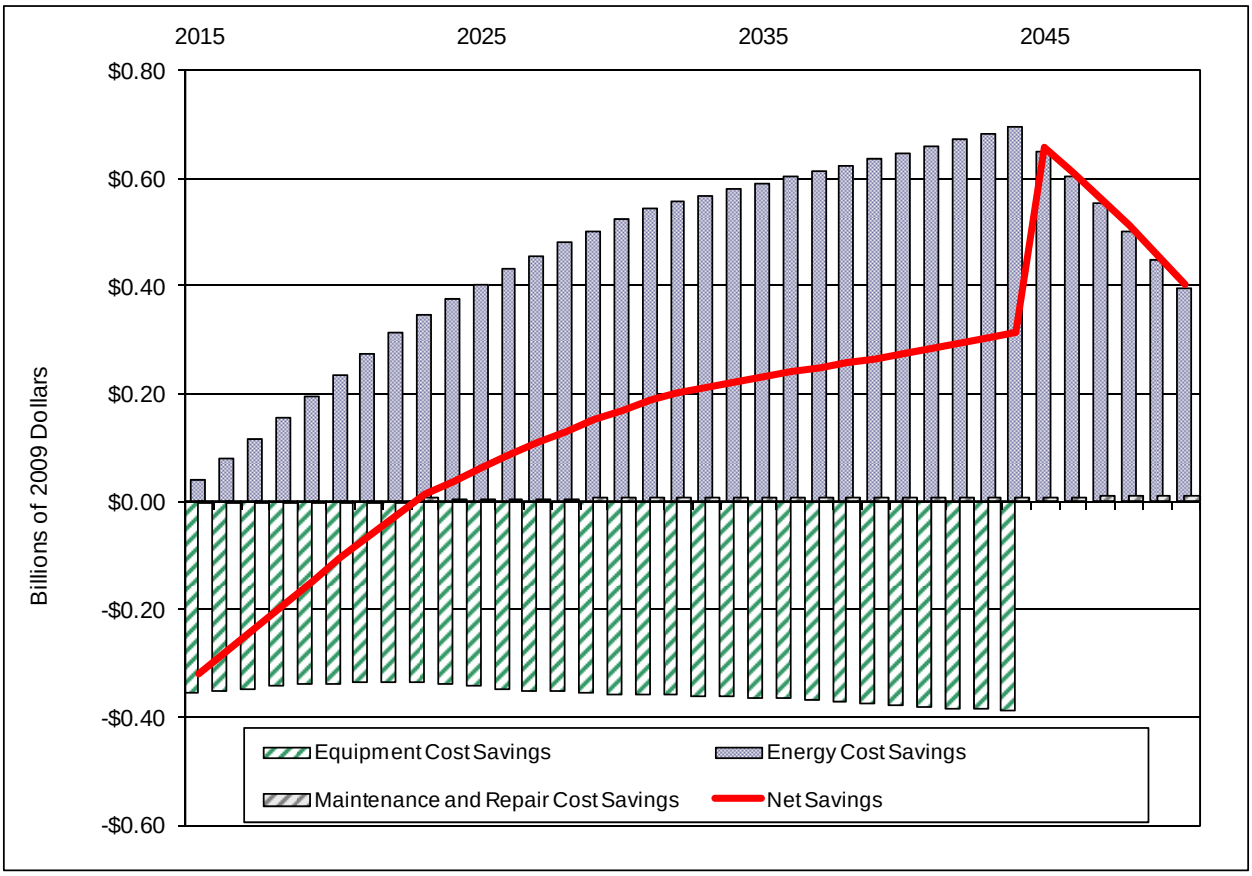

Figure 10.6.1 Non-Discounted Increases in Annual Installed Cost and Savings in Operating Cost for Gas-Fired Storage Water Heaters: TSL 5

10.6.4 Consumer Net Present Value Results

The following sections provide results from calculations of consumer NPV for the TSLs considered for each type of heating product. Results, which are cumulative, are shown as the discounted value of the net savings in dollar terms. Because DOE based the inputs to the NIA model on weighted-average values, results are discrete point values, rather than a distribution of values as produced by the LCC and PBP analyses.

The present value of total increased installed costs is the total annual increase in installed cost (i.e., the difference between the standards case and base case), discounted to the present and summed over the period for which DOE evaluates the impact of energy conservation standards. Savings are decreases in operating costs associated with the higher energy efficiency of products purchased in the standards cases compared to the base case. Total savings in operating cost are the savings per unit multiplied by the number of units of each vintage (year of manufacture) that survive in a particular year. For units purchased up through the final year (2043 or 2045), the operating cost includes energy consumed until the last unit is retired from service.

10.6.4.1 Water Heaters

Tables 10.6.9 and 10.6.10 show the results of calculating the consumer NPV at 3 and 7 percent discount rates for the TSLs analyzed for water heaters.

Table 10.6.9 Water Heaters: Cumulative Consumer Net Present Value, Discounted at 3 Percent

Product Class	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6	TSL 7	TSL 8
	Billion 2009 dollars							
Gas-Fired Storage	2.72	3.13	3.13	3.13	2.38	2.78	3.13	-7.47
Electric Storage	1.35	2.10	3.46	3.96	5.84	5.84	19.80	32.24
Oil-Fired Storage	0.08	0.15	0.22	0.22	0.22	0.22	0.22	0.38
Gas-Fired Instantaneous	0.24	0.24	0.24	0.24	0.24	0.24	0.24	-8.27
TOTAL	4.39	5.62	7.05	7.55	8.67	9.08	23.39	16.87

Table 10.6.10 Water Heaters: Cumulative Consumer Net Present Value, Discounted at 7 Percent

Product Class	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6	TSL 7	TSL 8
	Billion 2009 dollars							
Gas-Fired Storage	0.59	0.22	0.22	0.22	0.27	-0.10	0.22	-9.95
Electric Storage	0.35	0.61	0.85	0.73	1.03	1.03	-0.52	3.25
Oil-Fired Storage	0.03	0.06	0.09	0.09	0.09	0.09	0.09	0.15
Gas-Fired Instantaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-5.02
TOTAL	0.96	0.88	1.15	1.03	1.39	1.01	-0.22	-11.57

10.6.4.2 Direct Heating Equipment

Tables 10.6.11 and 10.6.12 show the results of calculating the consumer NPV at 3 and 7 percent discount rates for the TSLs analyzed for direct heating equipment.

Table 10.6.11 Direct Heating Equipment: Cumulative Consumer Net Present Value, Discounted at 3 Percent

Product Class	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
	Billion 2009 dollars					
Gas Wall Fan	0.06	0.07	0.07	-0.01	0.06	-0.01
Gas Wall Gravity	0.04	0.04	0.07	0.07	-0.12	-0.12
Gas Floor	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Gas Room	0.01	0.02	0.03	0.03	0.20	0.20
Gas Hearth	1.21	1.21	1.21	-1.35	-1.35	-5.04
TOTAL	1.32	1.34	1.39	-1.26	-1.22	-4.97

Table 10.6.12 Direct Heating Equipment: Cumulative Consumer Net Present Value, Discounted at 7 Percent

Product Class	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
	Billion 2009 dollars					
Gas Wall Fan	0.02	0.03	0.03	-0.03	0.02	-0.03
Gas Wall Gravity	0.01	0.01	0.02	0.02	-0.14	-0.14
Gas Floor	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Gas Room	0.00	0.01	0.01	0.01	0.07	0.07
Gas Hearth	0.50	0.50	0.50	-1.19	-1.19	-4.28
TOTAL	0.54	0.55	0.56	-1.19	-1.24	-4.38

10.6.4.3 Pool Heaters

Table 10.6.13 shows the results of calculating the consumer NPV at 3 and 7 percent discount rates for the TSLs analyzed for pool heaters.

Table 10.6.13 Pool Heaters: Cumulative Consumer Net Present Value Results

	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
	Billion 2009 dollars					
Discounted at 3%	0.10	0.10	-0.01	-0.15	-2.33	-4.57
Discounted at 7%	0.04	0.04	-0.06	-0.16	-1.39	-2.87

REFERENCES

1. Energy Information Administration, *Annual Energy Outlook 2010 (Early Release) with Projections to 2035*, 2010. Washington, DC. Report No. DOE/EIA-0383(2010). <**http://www.eia.doe.gov/oiaf/aeo/**>